CLAIMS

What is claimed is:

1. A method for combined digital pre-equalizing and pre-distorting signal processing of radio signals from a transmitter to multiple receivers over nonlinear channels with memory, the method comprising:

transmitting packets of radio signals on a plurality of radio links in a radio system;

pre-distorting amplitude and phase of complex M-ary quadrature amplitude modulated (QAM) signal constellations generated for multiple radio links by the transmitter on the plurality of radio links using pre-distorter amplitude and phase lookup tables;

estimating and storing amplitude-amplitude (AM/AM) and amplitude-phase (AM/PM) characteristics of a nonlinear high-power amplifier through a calibration ramp signal as a function of *M* distinct ambient temperature values covering a desired dynamic operating temperature range;

pre-distorting an incoming QAM signal by a complex gain which is a function of operating point of the high-power amplifier (HPA);

pre-equalizing transmitted bursts of multiple radio links using a programmable fractionally-spaced pre-equalizer with tap coefficients obtained from a calibrated system using an adaptive equalizer placed after a matching receiver square-root raised-cosine filter coupled to the high-power amplifier (HPA); and

pre-equalizing amplitude and group-delay variations corresponding to composite transmit analog filters as well as distortion of digital-to-analog converter using K complex pre-stored tap coefficients.

2. The method of claim 1 further comprising:

pre-distorting the amplitude of transmitted complex QAM signaling burst on the plurality of radio links using pre-characterized and pre-stored

AM/AM lookup tables that are addressed based on operating point of the high-power amplifier associated with an active link of the plurality of radio links.

3. The method of claim 2 further comprising:
extracting the linear behavior of the nonlinear amplifier from stored AM/AM characteristics by generating M pre-distorted amplitude lookup tables and M pre-distorted phase lookup tables corresponding to M different temperature values.

4. The method of claim 2 further comprising:
in a gain stage positioned prior to the high power amplifier of a signal path including the high power amplifier, setting a gain parameter value reflecting operating point of the high-power amplifier for the plurality of radio links.

5. The method of claim 2 further comprising:
selecting operating mode for addressing the amplitude lookup table based on one of squared magnitude of the incoming complex signal $(x^2 + y^2)$, real-squared magnitude (x^2) and imaginary-squared magnitude (y^2), wherein any operating mode could be used to get the appropriate table entry address for the stored pre-distorted AM/AM gain characteristics.

6. The method of claim 2 further comprising:
storing data in an additional lookup table, the data corresponding to characteristics of the high-power amplifier at different operating conditions of the high-power amplifier.

7. The method of claim 6 further comprising:

updating the data in the additional lookup table based on the stored characteristics of the high-power amplifier.

8. The method of claim 1 further comprising:
pre-distorting the phase of transmitted complex QAM signaling burst on the plurality of radio links using pre-characterized and pre-stored AM/PM lookup tables that are addressed based on operating point of the high-power amplifier associated with an active link of the plurality of radio links.

9. The method of claim 8 further comprising:
extracting the linear behavior of the nonlinear amplifier from stored AM/PM characteristics by generating M pre-distorted amplitude lookup tables and M pre-distorted phase lookup tables corresponding to M different temperature values.

10. The method of claim 8 further comprising:
in a gain stage positioned prior to the high power amplifier of a signal path including the high power amplifier, setting a gain parameter value reflecting operating point of the high-power amplifier for the plurality of radio links.

11. The method of claim 8 further comprising:
selecting operating mode for addressing the phase lookup table based on one of squared magnitude of the incoming complex signal ($x^2 + y^2$), real-squared magnitude (x^2) and imaginary-squared magnitude (y^2), wherein any operating mode could be used to get the appropriate table entry address for the stored pre-distorted AM/PM gain characteristics.

12. The method of claim 8 further comprising:
storing data in an additional lookup table, the data corresponding to characteristics of the high-power amplifier at different operating conditions of the high-power amplifier.

13. The method of claim 1 further comprising:
providing a pre-equalizer block;
providing a pre-distorter block coupled with the pre-distorter amplitude and phase lookup tables;
providing a feedback path including
a directional coupler to sample an output signal of the high-power amplifier;
means for switching out the feedback path;
cascaded filter means for bandlimiting and conditioning the sampled output signal; and
means for RF down conversion to baseband, analog-to-digital conversion, digital demodulation and symbol detection to provide a refined feedback signal to an adaptive algorithm block for updating complex coefficients of the pre-distorter amplitude and phase lookup tables.

14. The method of claim 13 further comprising:
generating N sets of complex tap coefficients for the programmable fractionally-spaced pre-equalizer corresponding to N different desired operating frequency bands.

15. The method of claim 14 further comprising:
measuring frequency responses of the desired frequency bands; and
storing appropriate resulting tap coefficients according to operating frequency bands for a given link.

16. The method of claim 15 further comprising:
storing tap-coefficient sets in a shadow register in order to reduce the impact of inter-burst interference of adjacent bursts due to possible insufficient guard time between bursts when the transmitter is switching from burst to burst during per link operation, the shadow register being accessed when the span of pre-equalizer tap coefficients exceeds allowable guard time between bursts.

17. The method of claim 1 further comprising:
transmitting one or more packets on a first radio link; and
transmitting one or more packets on a second radio link.

18. The method of claim 17 further comprising:
retrieving stored pre-distortion data for the first radio link prior to transmitting on the first radio link;
retrieving stored pre-distortion data for the second radio link prior to transmitting on the first radio link; and
pre-distorting using the retrieved pre-distortion data.

19. The method of claim 17 further comprising:
retrieving stored pre-equalization data for the first radio link prior to transmitting on the first radio link;
retrieving stored pre-equalization data for the second radio link prior to transmitting on the second radio link; and
pre-equalizing using the retrieved pre-equalization data.

20. A radio transmitter comprising:
a high-power amplifier;
a signal amplitude and phase pre-distorter coupled with the high-power amplifier;

one or more lookup tables coupled with the pre-distorter to store pre-distorter data related to operating characteristics of the high-power amplifier; and

a pre-equalizer coupled with the pre-distorter and the high-power amplifier.

21. The radio transmitter of claim 20 further comprising:

a filter circuit; and

a digital to analog converter.

22. The radio transmitter of claim 21 wherein the pre-equalizer is configured to compensate for variations introduced by the filter circuit and the digital to analog converter:

23. The radio transmitter of claim 20 wherein the pre-distorter comprises:

a mode select input to receive a select mode signal.

24. The radio transmitter of claim 23 wherein the pre-distorter comprises:

a power estimator responsive to the mode signal for estimating power of an input signal.

25. The radio transmitter of claim 24 wherein the power estimator is configured to estimate power of the input signal according to one of

a squared magnitude of a complex input signal,

a real squared magnitude of the complex input signal, and

an imaginary squared magnitude.

26. The radio transmitter of claim 25 wherein the pre-distorter is configured to use the power estimate to index the lookup table.

27. The radio transmitter of claim 20 wherein the pre-distorter comprises:

an automatic level control register to store a power level settings, the power level settings being used to determine gain of the pre-distorter.

28. The radio transmitter of claim 20 further comprising:

a feedback path including an adaptive block, the adaptive block being configured to update the pre-distorter data stored in the one or more lookup tables.

29. A calibration method for a radio transmitter, the calibration method comprising:

(a) applying a calibration ramp signal to a pre-distorter of the radio transmitter;

(b) pre-distorting the calibration ramp signal to produce a pre-distorted signal;

(c) amplifying the pre-distorted signal in a high-power amplifier;

(d) sampling an output signal from the high-power amplifier;

(e) based on the calibration ramp signal and the sampled output signal, generating at least one of amplitude-to-amplitude and amplitude-to-phase characteristic data; and

(f) storing the characteristic data for subsequent use during operation of the radio transmitter.

30. The calibration method of claim 29 further comprising:

repeating acts (a) through (f) for different operating conditions of the radio transmitter.

31. The calibration method of claim 30 further comprising:

repeating acts (a) through (f) for different operating temperatures of the radio transmitter.

32. The calibration method of claim 29 wherein generating at least one of amplitude-to-amplitude and amplitude-to-phase characteristic data comprises:

determining an output signal due to the calibration ramp signal; and

based on the output signal, generating inverse data.

33. The calibration method of claim 29 wherein generating inverse data comprises:

inverting amplitude data to produce inverse AM/AM data; and

negating phase data to produce inverse phase data;

34. The calibration method of claim 29 wherein generating inverse data further comprises:

compressing some of the inverse AM/AM data to reduce dynamic range of the inverse AM/AM data.